End-to-End Medium Rate Telemetry System Test

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An end-to-end test of the operational medium rate Telemetry System was conducted on May 23, 1972. The errors recorded seem to group themselves around three patterns: those errors associated with 360 computer time corrections, those errors concerned with Ground Communications Facility (GCF) transmission, and those errors apparent in the GCF/synchronizer/360 interface. Noise on the data-block-detected signal from the GCF decoder to the SFOF synchronizers is suspected. A recommendation is made for a facility test between the GCF and SFOF to be undertaken to validate the quality of the data-block-detected signal per transfer agreement and assembly specifications.

I. Introduction

Numerous instances have been reported involving the unreliable operation of the DSN Medium Rate Telemetry System during support of early phases of the *Pioneer 10* mission. The system includes the processing of coded and uncoded data at rates between 50 and 2500 bps. Specific anomalies observed have been the inability of the system to maintain frame synchronization for more than approximately 10 minutes without a data interruption or the appearance of "short blocks" i.e., incomplete high-speed data (HSD) blocks received at the Space Flight Operations Facility (SFOF). Since the causes of the problem(s) were not obvious, the DSN Telemetry Design Team recommended an end-to-end medium rate Telemetry System test. This test was conducted on May 23, 1972.

II. Test Configuration

As shown in Fig. 1, DSS 71 and CTA 21 were used in this test along with the 360/75 SFOF computer. The Simulation Conversion Assembly (at DSS 71) generated *Pioneer 10* fixed-pattern formats which were converted to RF signals for DSS 71 processing. Besides the normal telemetry original data record (ODR), DSS 71 had a Digital Instrumentation Subsystem (DIS) program and a

HSD ODR program in the spare Telemetry and Command Processor (TCP) that printed and logged the data as seen on the output of the Ground Communications Facility (GCF) data set and TCP. CTA 21 looked at DSS 71's data via a separate communication line from DSS 71/Goddard, with the same TCP ODR and DIS programs logging and printing errors for received HSD blocks. At JPL, the GCF monitored data-block-detected status on its Printer-Punch-Recorder (PPR). Also, as shown in Fig. 1, two data sets were used to drive all four synchronizers in the SFOF, using the signal from DSS 71. Synchronizers 2 and 4 were driven by the data-block-detected signal (all data mode) from the SFOF Communication Terminal, while synchronizers 1 and 3 were in the forced-check mode (derive sync from HSD block, i.e., internal synchronization). The GCF provided a hard copy test record from their PPR and the SFOF 360/75 printed alarm messages on teletypewriters (TTY), while also maintaining a digital log. The test was run at data rates of 1024 and 2048 bps in the convolutional coded mode.

III. Discussion

Condensed results of the test are shown in Table 1. Each anomalous event and time is shown in comparison with: (1) what the synchronizers and 360/75 received; (2) what the GCF received (PPR); (3) what CTA 21 recorded (DIS TCP programs); and, finally, (4) what DSS 71 transmitted (DIS TCP programs). For a scheduled 8-hour test, over seven hours of test data were obtained and recorded. The error events exhibited in this test seem to group themselves around the following patterns; namely, those errors associated with 360 time corrections (events 10, 12, 13, 15), those errors concerned with GCF transmission (1, 2, 3, 4, 5, 6, 7, 8, 9, 16, 18, 19) and those errors spawned in the GCF/synchronizer/360 interface (11, 14, 17).

Concerning the first error pattern, 360/75 time corrections, the facility representative provided the following information. The time tags on the telemetry data received in the SFOF via HSD can be in error due to noise on the HSD line or incorrect time tagging of the data at the DSS. If the time parameters in the HSD blocks exceed the specified limit, the time tag is considered to be in error and a corrected time tag is used if possible. Based on a re-examination of the DSIF data, events 12, 13, and 15 can be attributed to hits on the GCF HSD line while event 10 was due to a TCP outage at DSS 71 because of re-initialization.

In reference to the second group of errors, NASCOM performance is quoted as:

(1) Undetected bit error rate: $< 10^{-10}$

(2) Detected bit error rate:

2 bits in 10^5 bits – one link

4 bits in 10^5 bits – two links

6 bits in 10^5 bits – three links

(3) Errors occur in bursts of from 3 to 200 bits in an HSD block with an average burst length of 15 bits

(4) Block throughput: $\geq 98\%$ (percent of error-free blocks)

The GCF representative, in analyzing the PPR data, concluded that the errors experienced during this test for the GCF were within specifications. The block throughput for the test was 99.37%. It should be noted that, contemporaneously with this end-to-end system test, the live *Pioneer F* track was exhibiting periodic frame sync loss while being processed in the same 360/75 computer as the test data.

Concerning the last group of errors, events 11, 14, and 17 were isolated to the GCF/synchronizer/360 interface. Two types of errors were noted; namely, the short block problem (11) and the independent operation of synchronizers 2 and 4 (14, 17). At time 17:52:44 the short blocks from all four synchronizers were due to a 360/75 loop condition which necessitated a manual reset/select action on the computer. Synchronizers 2 and 4 were driven by the data-block-detected signal from separate decoders in the GCF. Noise on this signal is suspected of causing errors in data format to be transferred to the 360/75. A patch-field condition existed such that the block-error-detected signal to the PPR could trigger the synchronizers with a false data-block-detected signal. However, at the time of the test, it was not clear that this was a problem. This has subsequently been corrected. This interference with the data-block-detected signals could also account for overlay blocks being received by the 360/75, although the SFOF printer may not be printing all occurrences of short blocks. At 2048 bps, the Telemetry System is using three of the four data blocks which are transferred to the 360 computer each second. At lower bit rates, the synchronizer interference problem could have gone undetected because of the discarding of filler blocks; only one of the four HSD blocks each second contained data.

IV. Conclusions

For a throughput of 99%, on the average for a single GCF link, one could expect one block in error for every 100 serviced. Although the incidence of GCF errors did not approach this average, errors were present. It should also be noted that during this test we processed over an hour of 2048 coded data without incident while servicing real *Pioneer* data in the same 360 computer. A recommendation is made for a facility test between the GCF and SFOF to be undertaken to validate the quality of the data-block-detected signal per transfer agreement and assembly specification. A future end-to-end medium rate test is again planned.

Table 1. Medium Rate Telemetry System test data condensation

Event as alarmed in 360/75	Time of event	360/75 synchronizer behavior	GCF behavior		CTA 21 notation	DSS 71 notation
			Error in data-block-detected signal	Block errors detected		
1. Missed data block; sync lost	15:06:58	Blocks accountable	0	8	No errors	No errors
2. Missed data block; sync lost	15:08:55	Blocks accountable	2	2	HSD SN error at 150856	No errors
3. Missed data block	15:11:24	Blocks accountable	0	2	No errors	No errors
4. Missed data block	15:15:46	Blocks accountable	2	7	GCF error at 151548	No errors
5. Sync lost	15:16:17	Blocks accountable	2	7	No errors	No errors
6. Missed data block	15:34:56	Blocks accountable	2	2	GCF error at 153443	No errors
7. Sync lost	15:39:13	Blocks accountable	0	1	No errors	No errors
8. Missed data block	16:03:55	Blocks accountable	2	2	No errors	No errors
9. Missed data block; sync lost	16:28:26	Blocks accountable	0	1	No errors	No errors
10. Time correction started error	16:49:00	Blocks accountable	0	0	No errors	No errors
11. Missed data block; sync lost	17:52:46	Sync 2 missed block SN 1203; other blocks accounted for	0	0	No errors	No errors
12. Time correction started error	17:56:41	Blocks accountable	0	2	No errors	No errors
13. Time correction started error	18:03:29	Blocks accountable	0	2	No errors	No errors
14. Sync lost	18:07:58	Sync 4 block SN 10851 stopped; then started with SN 10852	0	2	No errors	No errors
15. Time correction started error	18:58:26	Blocks accountable	0	1	No errors	No errors
16. Missed data block; sync lost	19:08:13	Blocks accountable	2	2	No errors	No errors
17. Missed data block; sync lost	19:11:20	Sync 4 missed data block; other blocks accounted for	2	0	No errors	No errors
18. Sync lost	19:32:21	Blocks accountable	0	1	No errors	No errors
19. Missed data block; sync lost	19:58:07	Blocks accountable	2	2	No errors	No errors

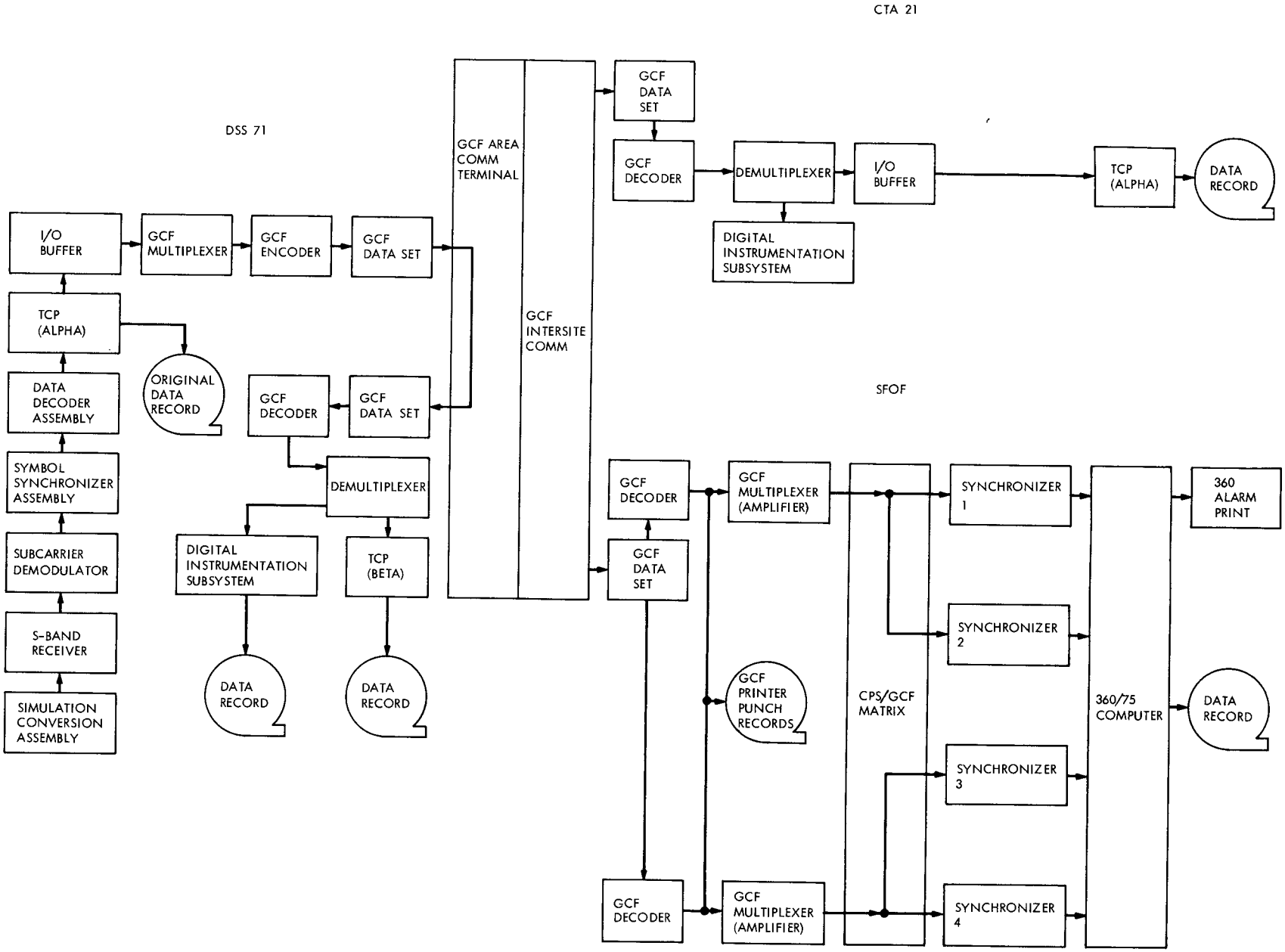

Fig. 1. Medium rate telemetry data flow